TeV Particle Astrophysics

TeVPA 2026

GRB 260226A

An Exceptionally Bright Gamma-Ray Burst Observed by *Fermi*-GBM and LAT

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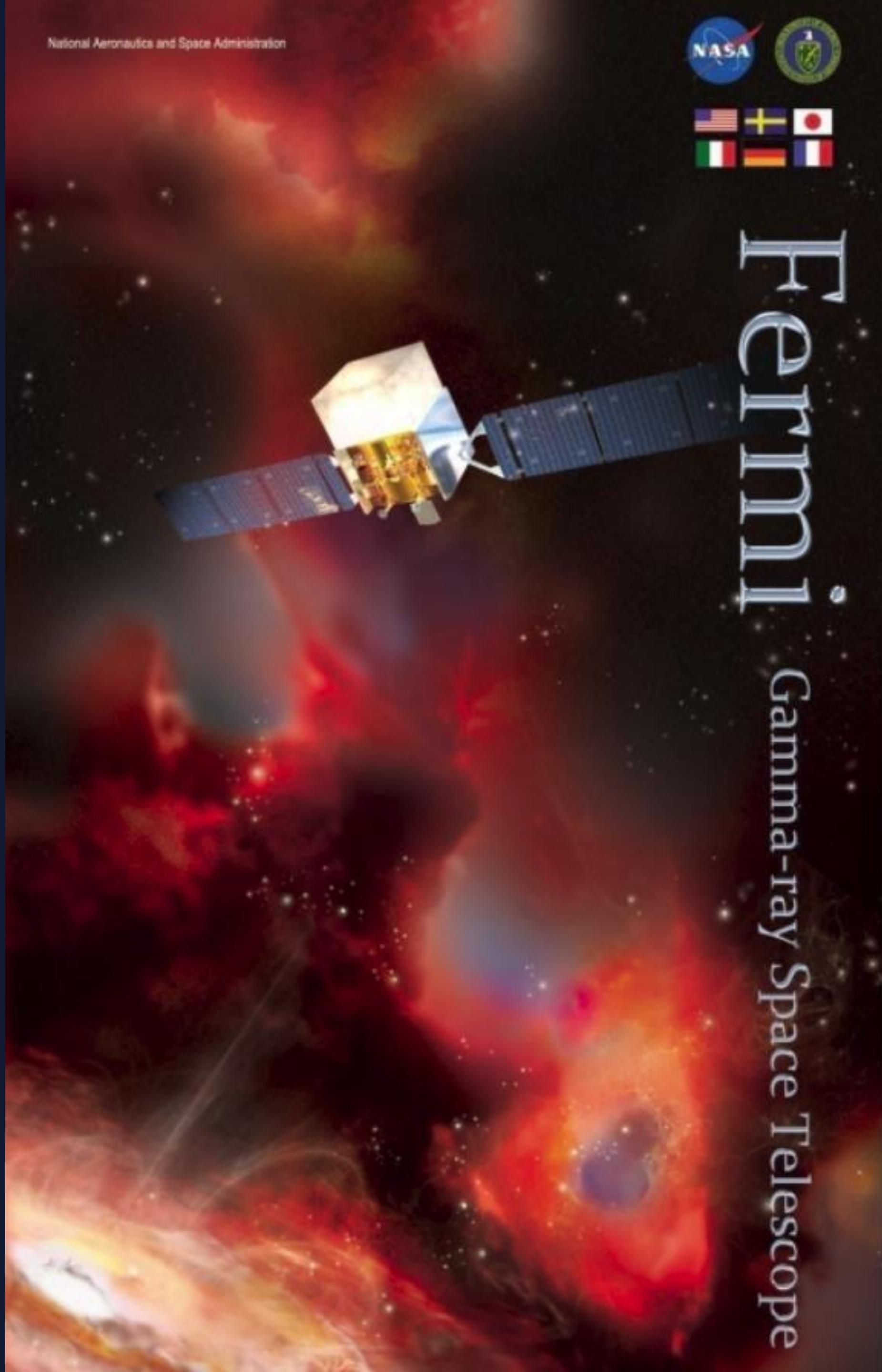
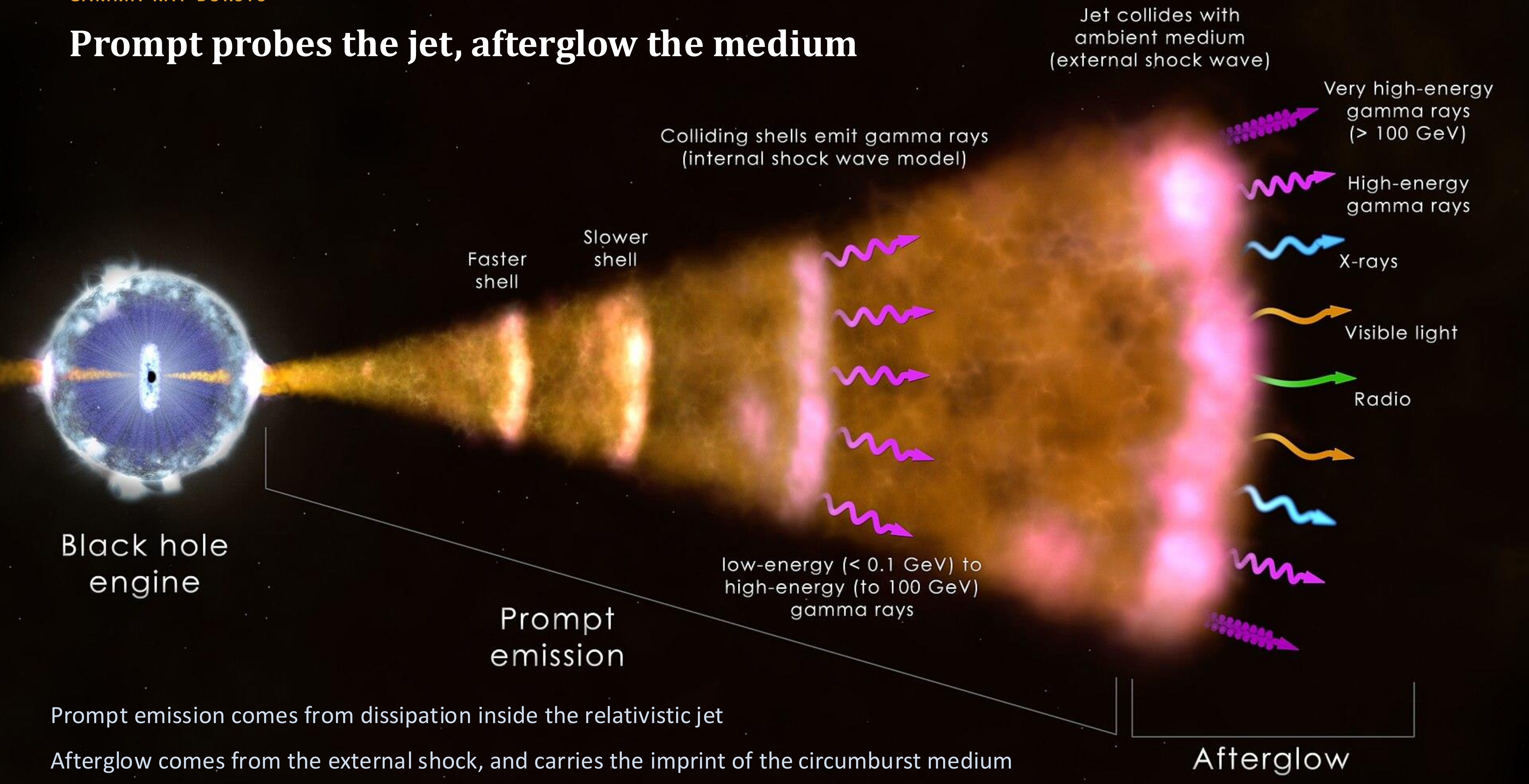
On behalf of the Fermi LAT and GBM collaborations



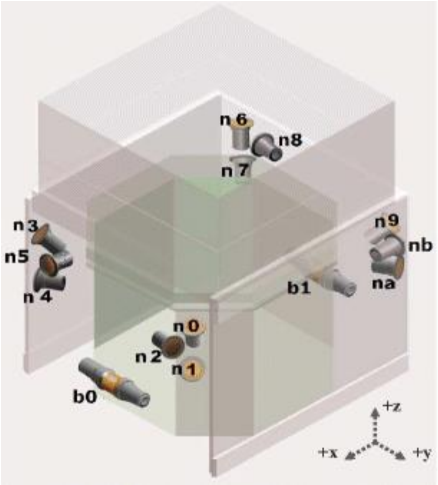
Prompt probes the jet, afterglow the medium



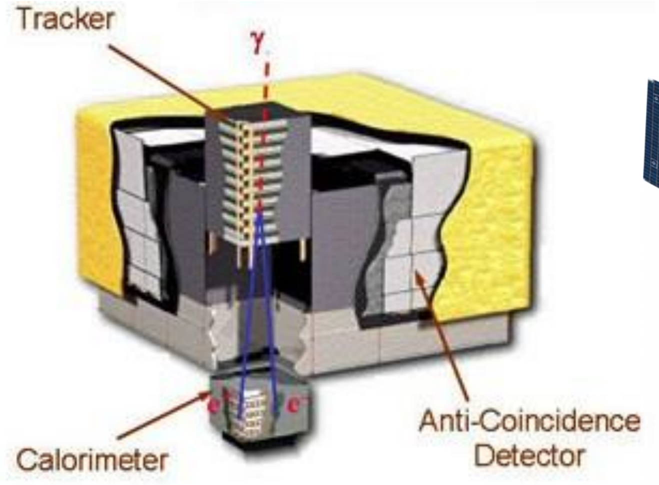
Prompt emission comes from dissipation inside the relativistic jet

Afterglow comes from the external shock, and carries the imprint of the circumburst medium

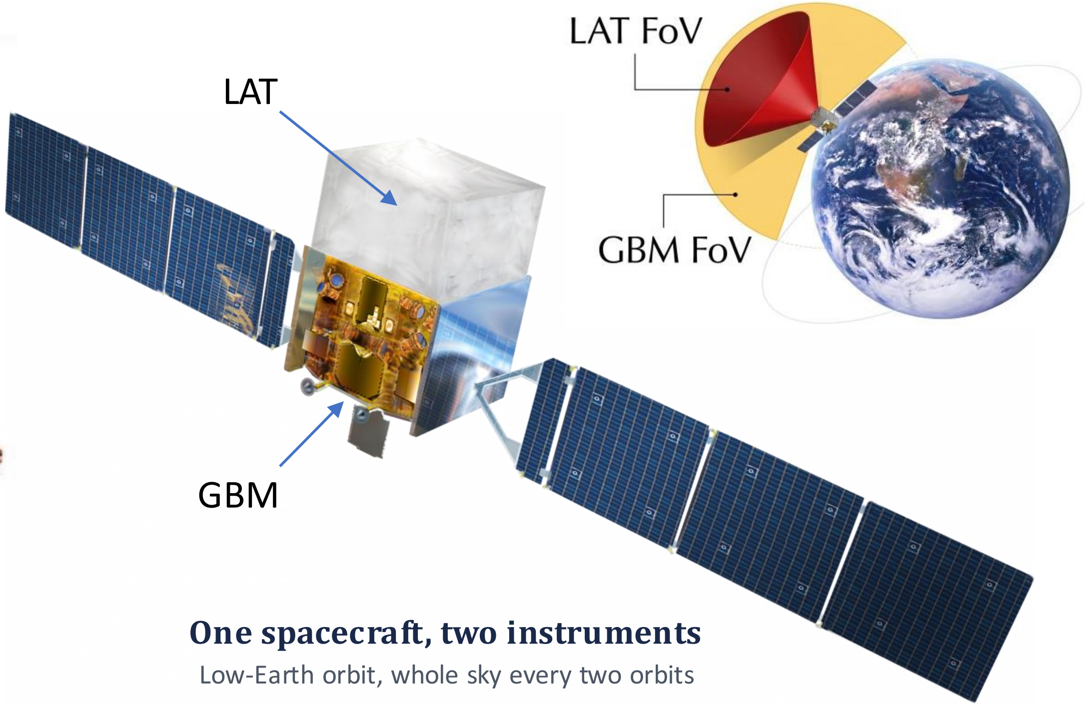
Continuous keV–GeV coverage from *Fermi*



GBM — 12 NaI + 2 BGO

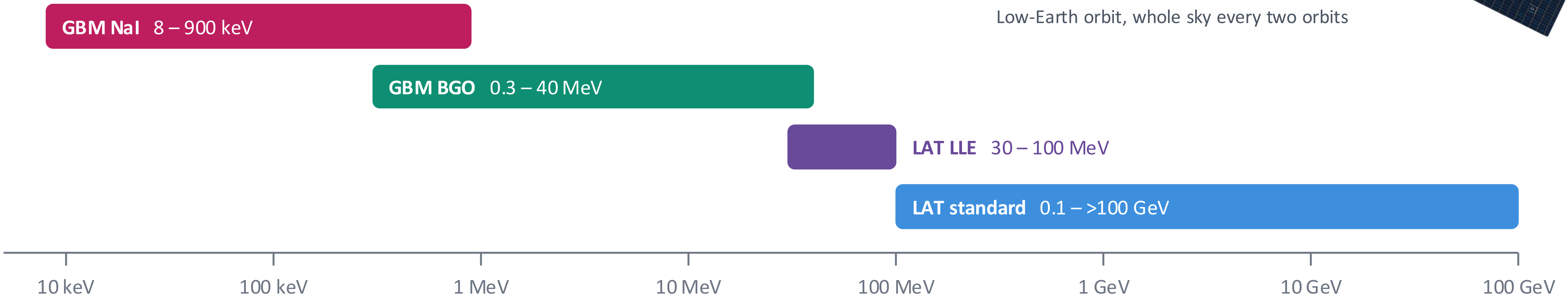


LAT — pair-conversion telescope



One spacecraft, two instruments

Low-Earth orbit, whole sky every two orbits



GRB 260226A: an exceptionally bright GRB

> 600

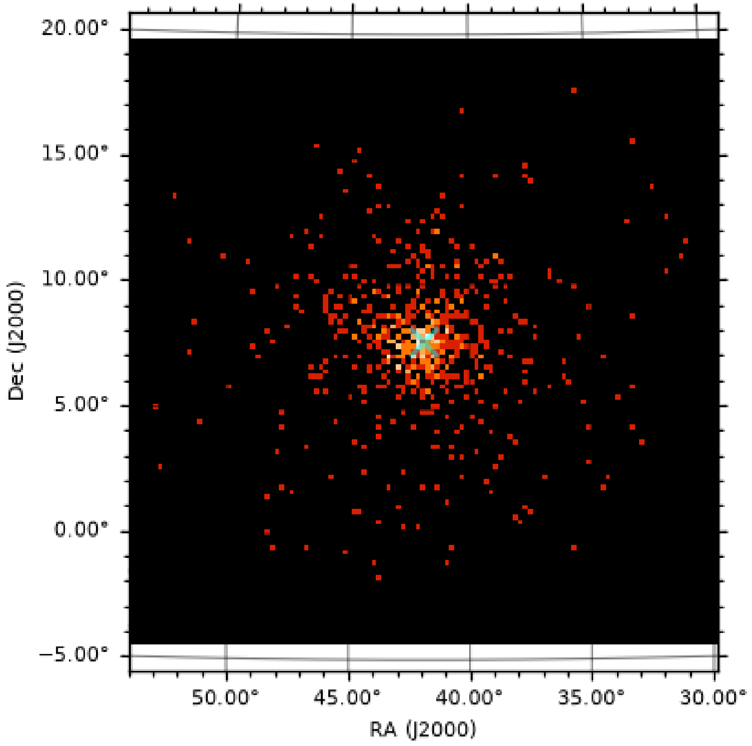
LAT photons above 100 MeV in the first 1000 s, with highest energy photon a 1.1 GeV at T0+420 s

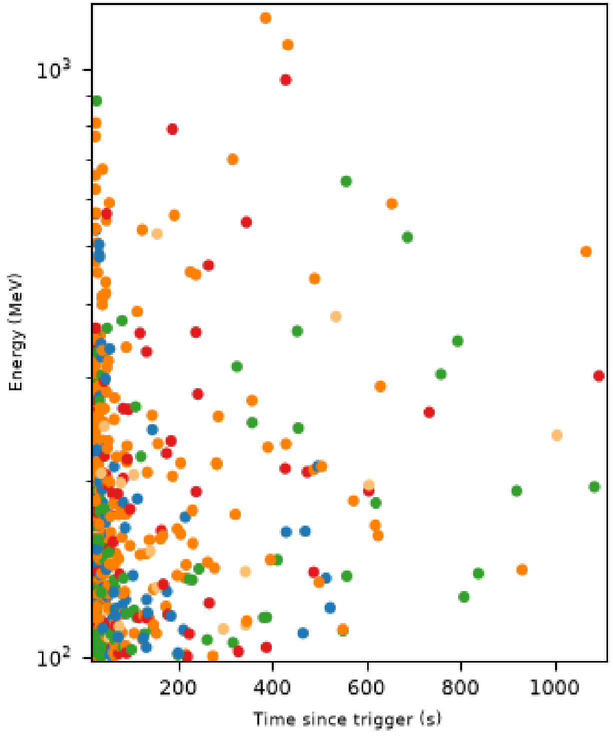
2nd

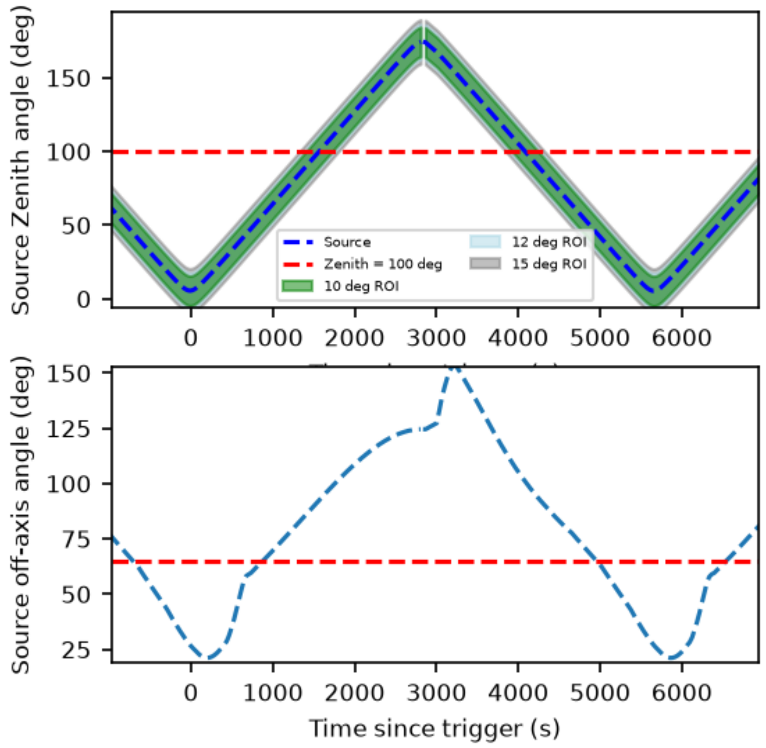
autonomous onboard LAT alert seeded by LAT in mission history after GRB 090510

26°

boresight angle at trigger time, while remaining for ~ 1000 s in the LAT field of view



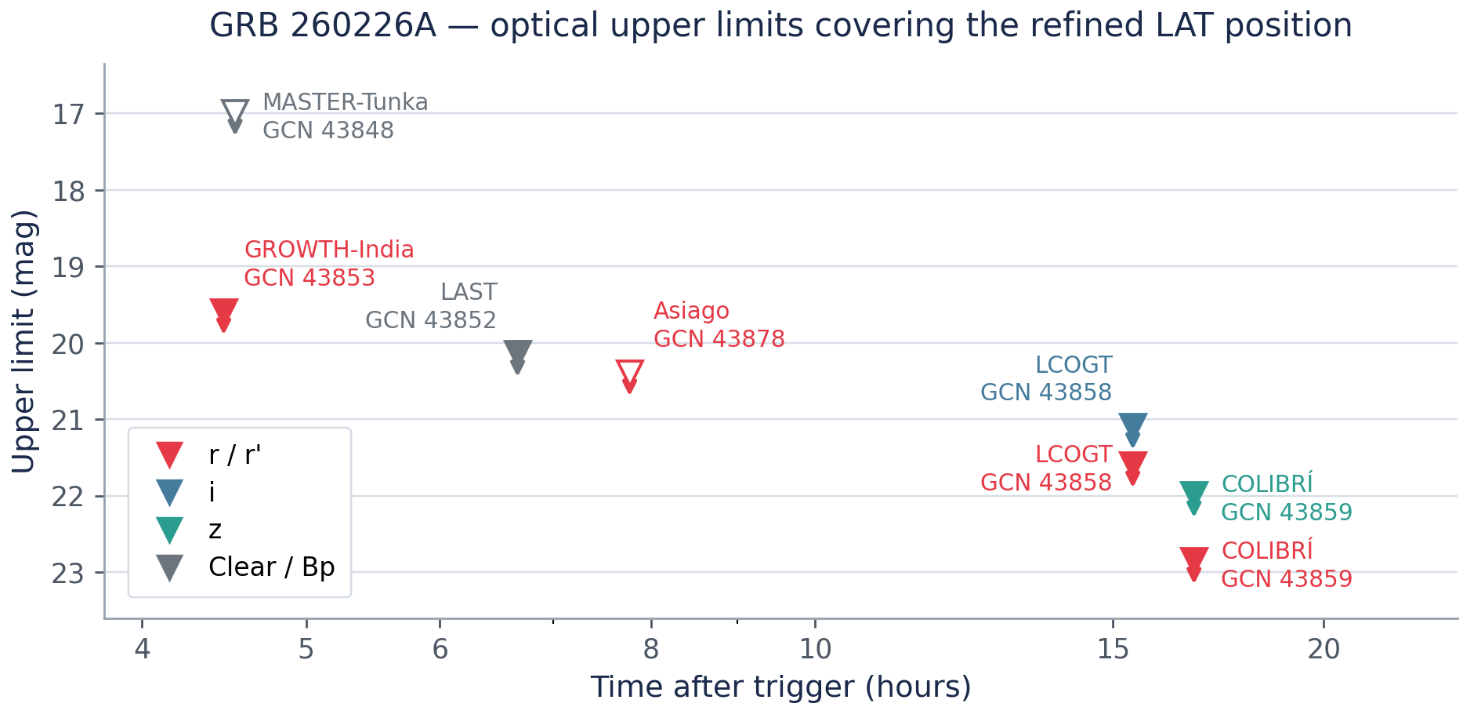




T_0 = 2026 February 26, 10:37:55 UTC · Localized by LAT at R.A. = 41.93°, Dec. = +7.73° +/- 0.11° (J2000)

Deep optical limits, and no redshift

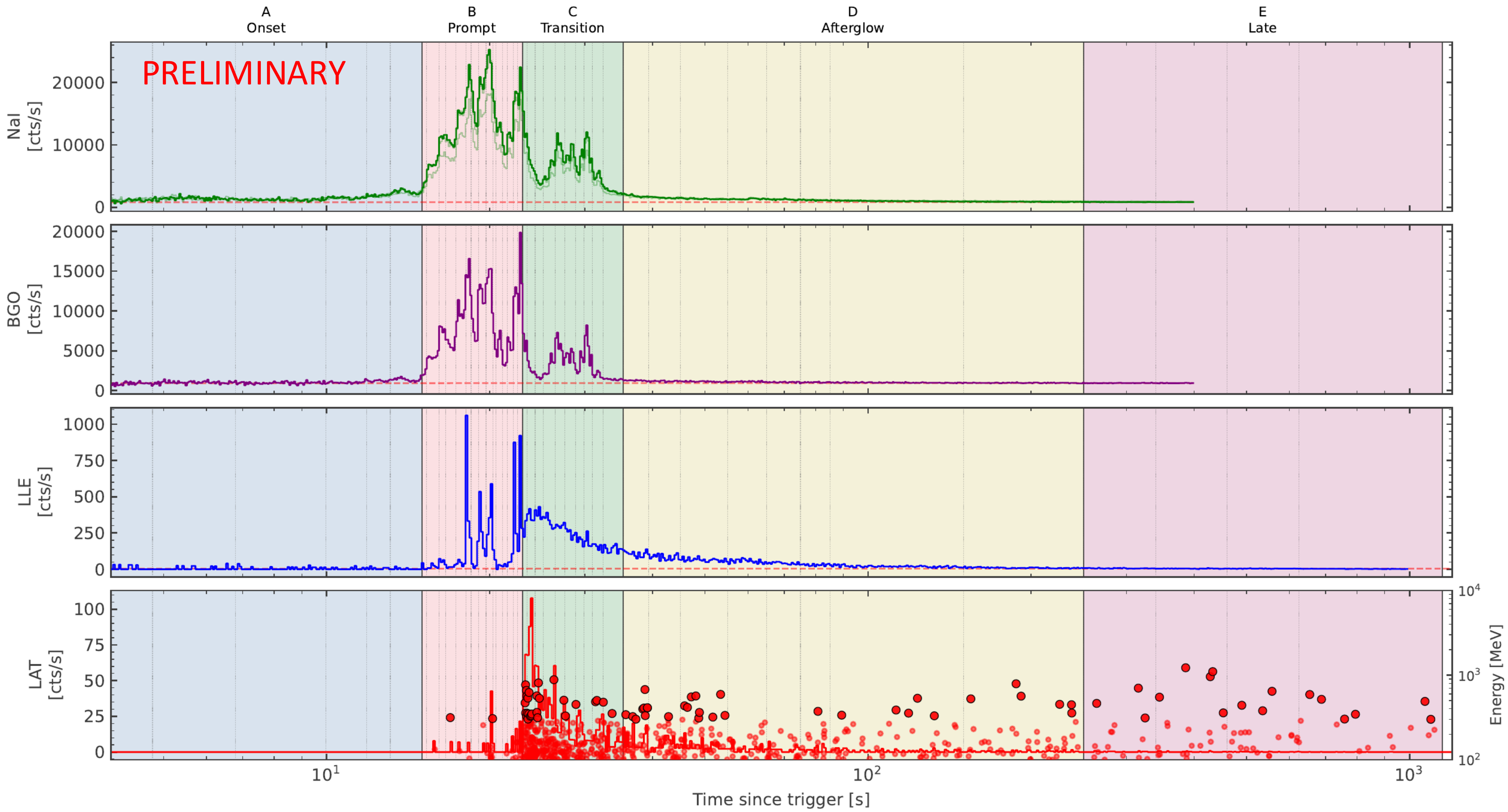
- Thanks to the LAT onboard trigger, a preliminary approximate GRB localization was distributed via GCN Notices as soon as few minutes from the trigger time.
- Unfortunately, Swift ToO capabilities were suspended for the reboost, SVOM and EP telescopes were Sun-constrained, IACT instruments had bad weather due to the Moon.



No optical counterpart detected

- GRB detected in hard X-rays or gamma rays by AstroSat CZTI, NuSTAR, Glowbug, CALET GBM, Konus-Wind, Insight-HXMT/HE
- Eight optical upper limits from six facilities — MASTER-Tunka, GROWTH-India, LAST, Asiago, LCOGT and COLIBRÍ (spanning 4.5 to 17 hr after trigger)
- Deepest: r > 22.86 AB (5σ) at 16.8 hr, from COLIBRÍ.
- Deep enough to disfavor a typical low-redshift afterglow.

One burst, four datasets, five phases



A **Onset** −2.3 → 15 s *GBM only*

B **Prompt** 15 → 23 s *GBM+LLE+LAT*

C **Transition** 23 → 35.3 s *GBM+LLE+LAT*

D **Afterglow** 35.3 → 250 s *GBM+LLE+LAT*

E **Late** 250 → 1150 s *LAT only*

Binning, fitting, modeling and background

1

Data-driven binning

Bayesian Blocks ($p_0 = 10^{-4}$) on the brightest available detector, merged until each bin meets an instrument-specific count floor: ≥ 15–20 LLE counts per channel, ≥ 25–30 LAT photons above 100 MeV where a high-energy component must be constrained.

2

Energy ranges and background

NaI (0, 1, 3): [10—900 keV] (excluding the iodine K-edge), BGO 0: [250 keV—40 MeV], LLE: [30—100 MeV], LAT: [100 MeV—10 GeV]. Polynomial fit for background estimation on [−400, −50] s and [500, 650] s.

3

LAT IRFs and diffuse components

P8_TRANSIENT020 event class. Included 4FGL-DR4 source catalog and Isotropic and Galactic templates with normalizations frozen at 1.0.

4

Joint spectral fits

GBM NaI + BGO, LLE and LAT fitted simultaneously in **3ML** with cross-calibration constants and using the unbinned likelihood analysis provided by *fermitools.*

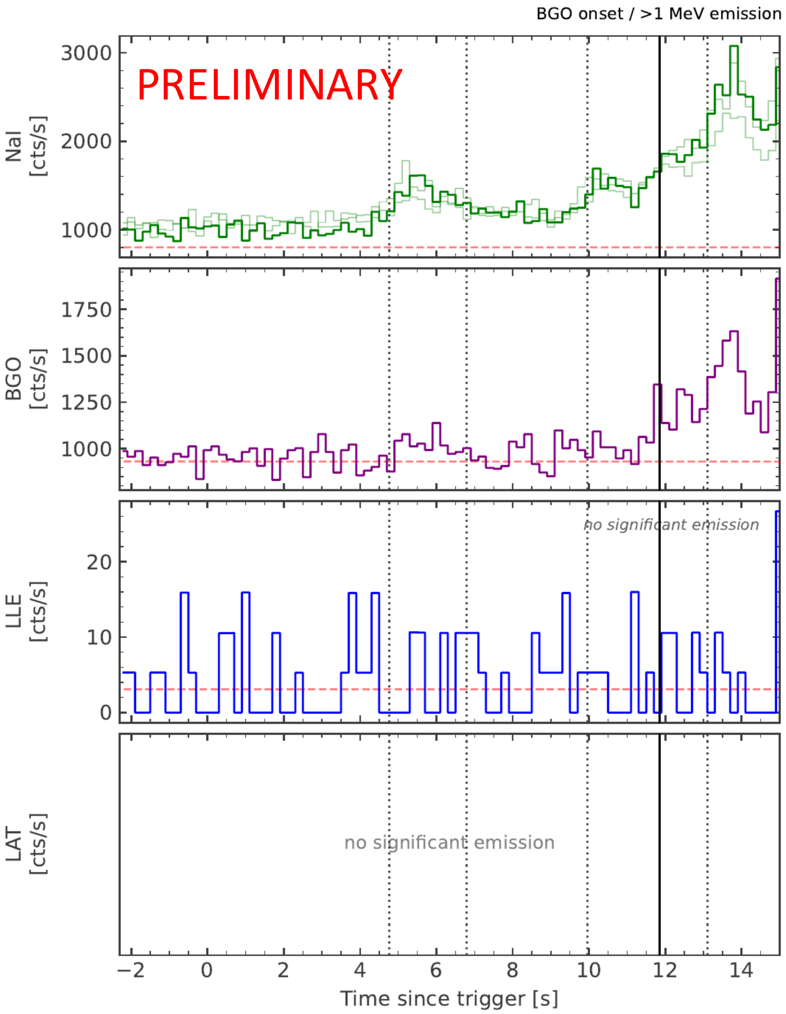
5

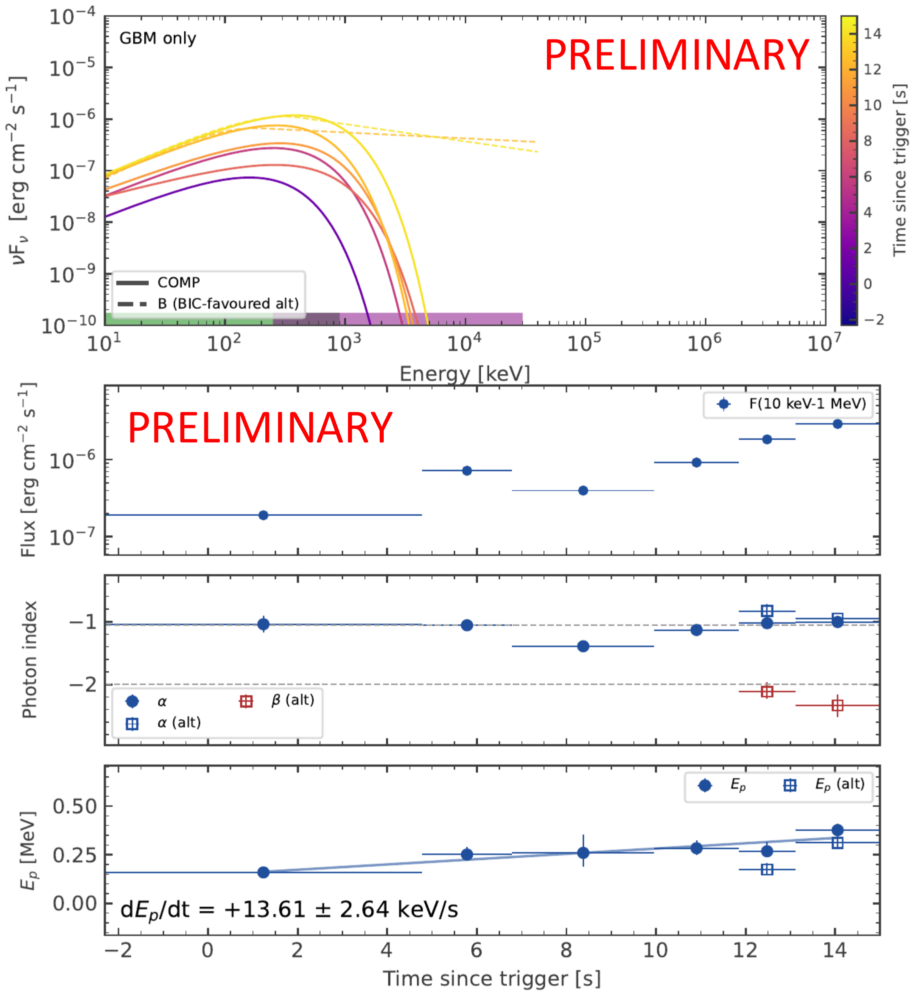
Models

Best-fit model selected with BIC among Cutoff Powerlaw, Blackbody, Band, Band x ExpCutoff, Band + Band, Band + Cutoff Powerlaw, Cutoff Powerlaw + Band, Cutoff Powerlaw + Cutoff Powerlaw, Powerlaw.

The burst starts ~ 17 s before the prompt phase

A





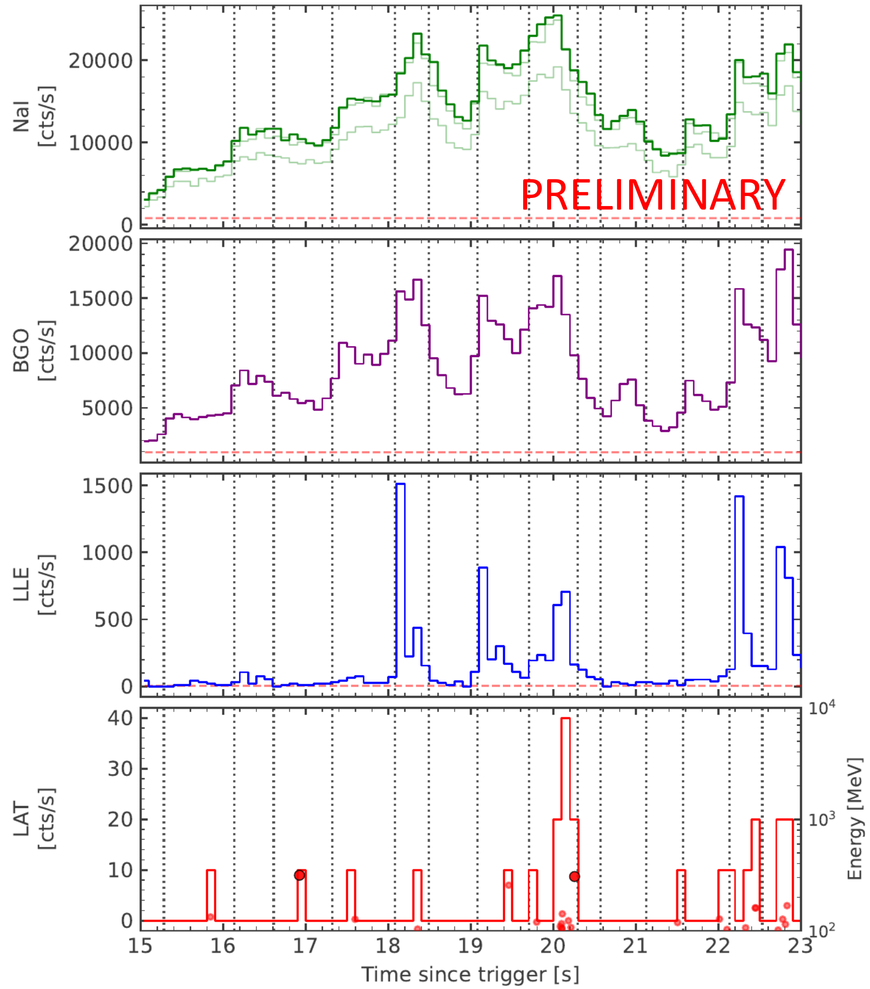
~ −2.3 s

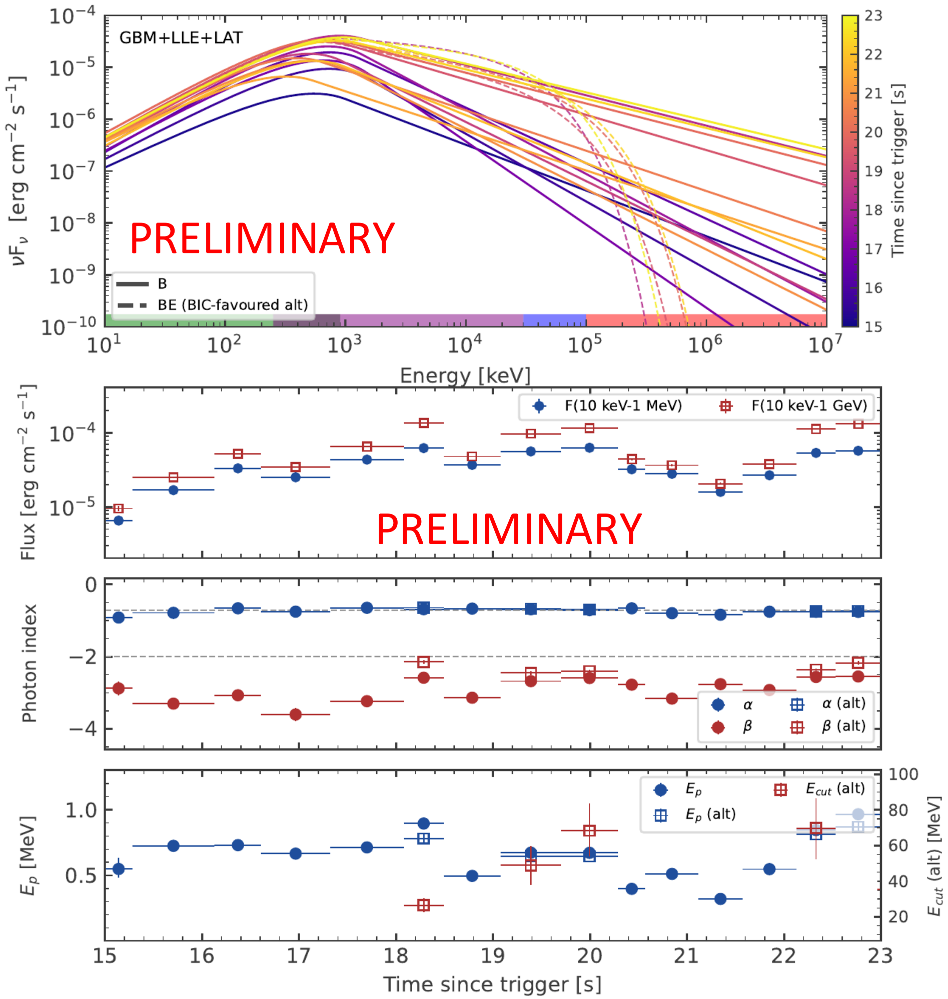
first significant GBM emission

- Onset stable against detector and threshold: n0 −2.28 s, n1 −2.21 s, unchanged for $p_0 = 10^{-2}$ to 10^{-4}.
- **Non-thermal throughout**: best-fit with Cutoff Powerlaw and Band, Blackbody rejected at ΔBIC > 190.
- E_p rises 159 ± 25 → 377 ± 32 keV while α constant at ≈ −1.06.
- Significant emission above 1 MeV appears at T_0 + 11.9 s .
- Nothing significant above 30 MeV in LLE and LAT

A prompt high-energy cutoff and a pause

B





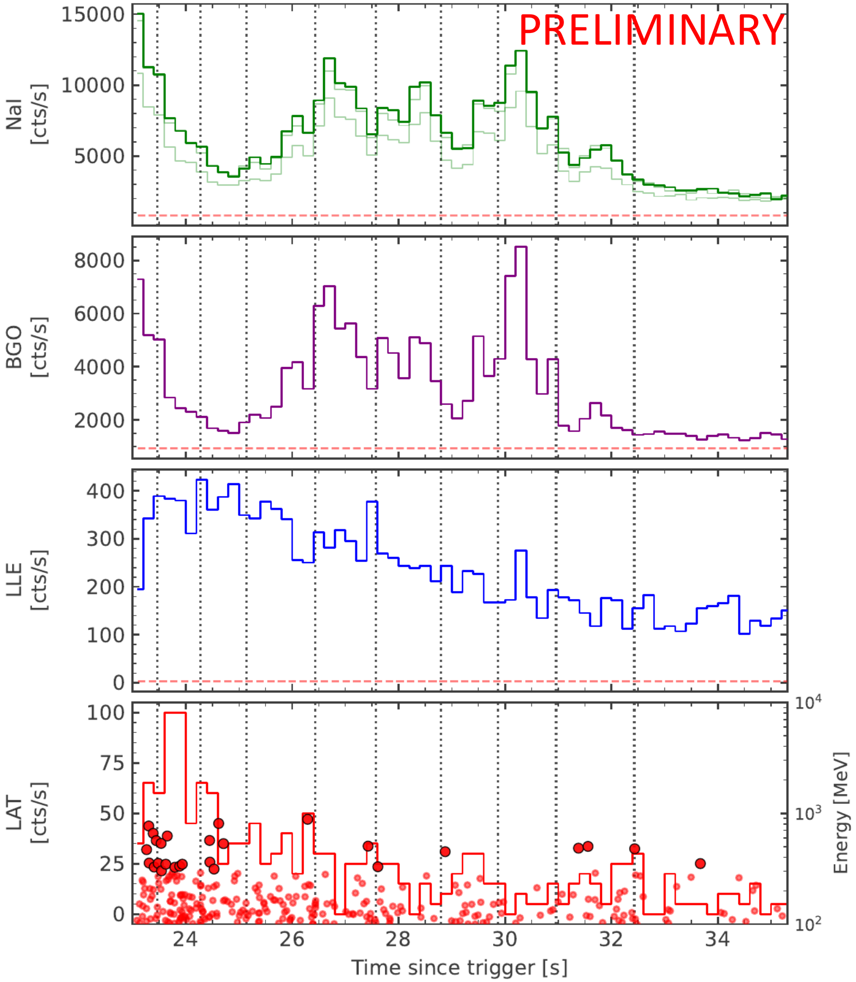
26 → 70 MeV

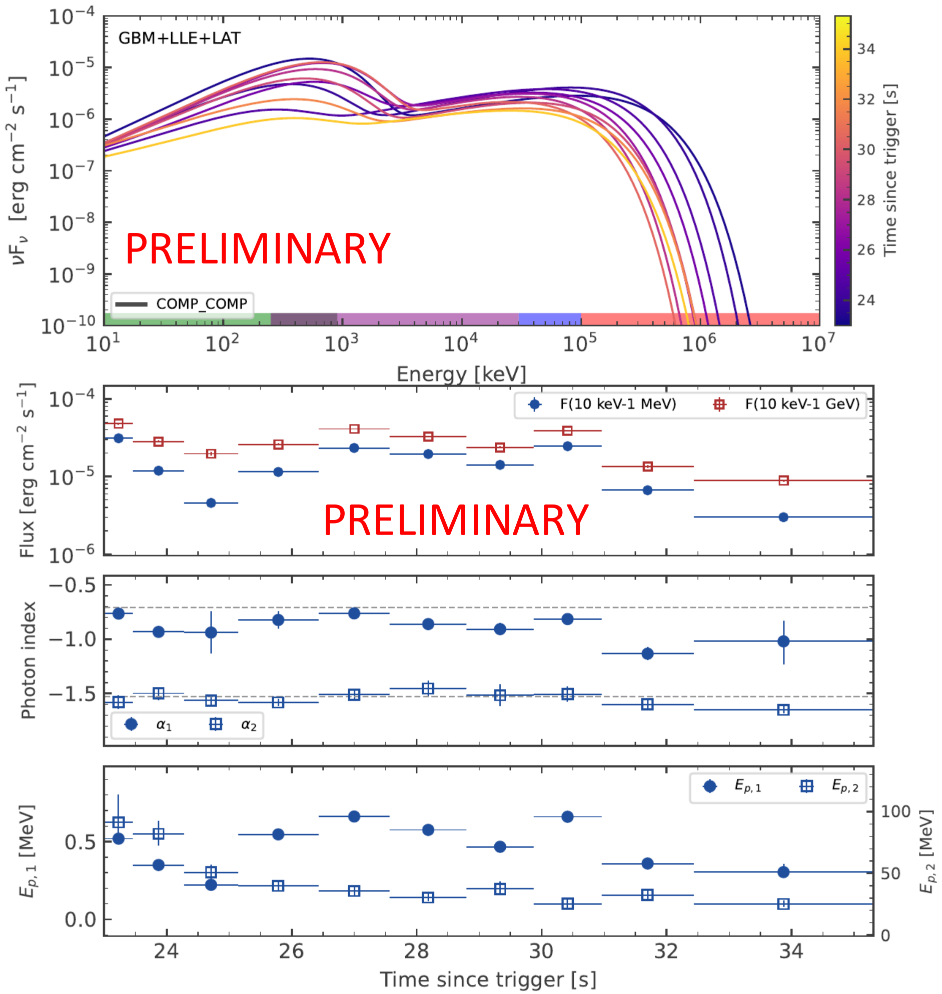
time-resolved high-energy cutoff

- **Climbing high-energy cutoff 26.5 ± 3.9 → 69.8 ± 16.9 MeV**, statistically detected in four bins.
- Spectrum extends upward in energy over time, consistent with declining opacity in the jet.
- Two main episodes (15–20.6 s, 22.1–23 s) separated by an energy-dependent pause at 20.6–22.1 s.
- Best-fit model is Band (or Band x ExpCutoff) with α ≈ -0.71 and Ep ~ 702 keV in the LLE-bright bins vs 410 keV in the pause.
- The tail is largely unconstrained and model dependent (β −2.3 with a cutoff, −3.1 without).

Two components, and the prompt one eventually dies

C





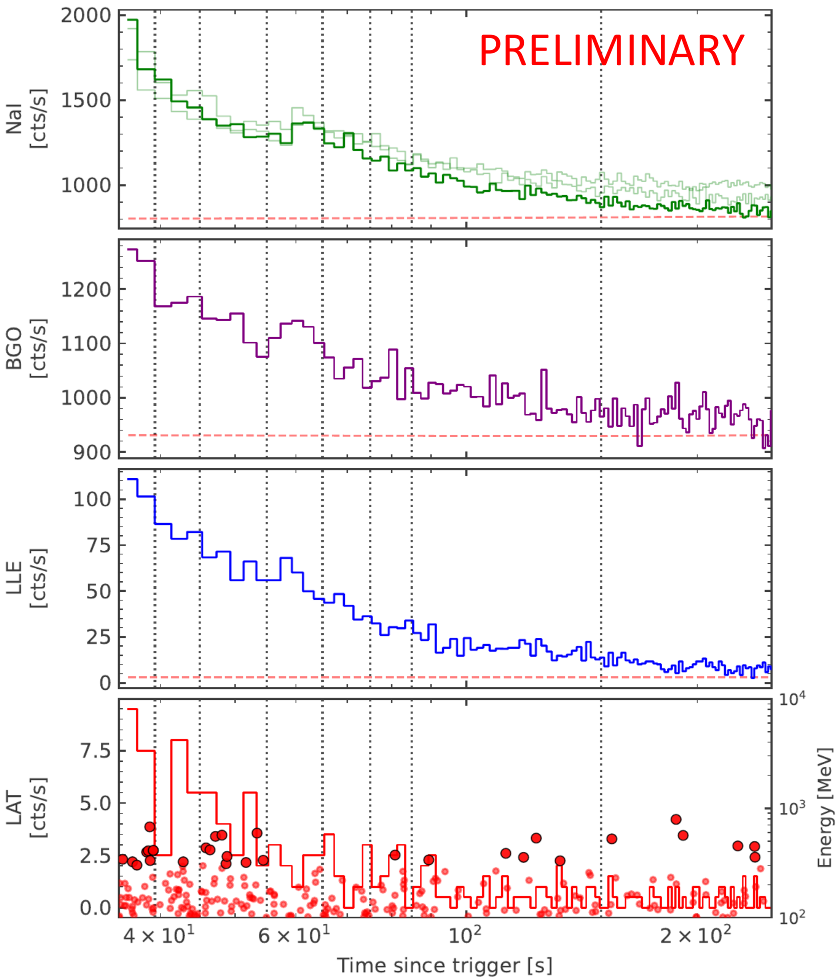
91 → 25 MeV

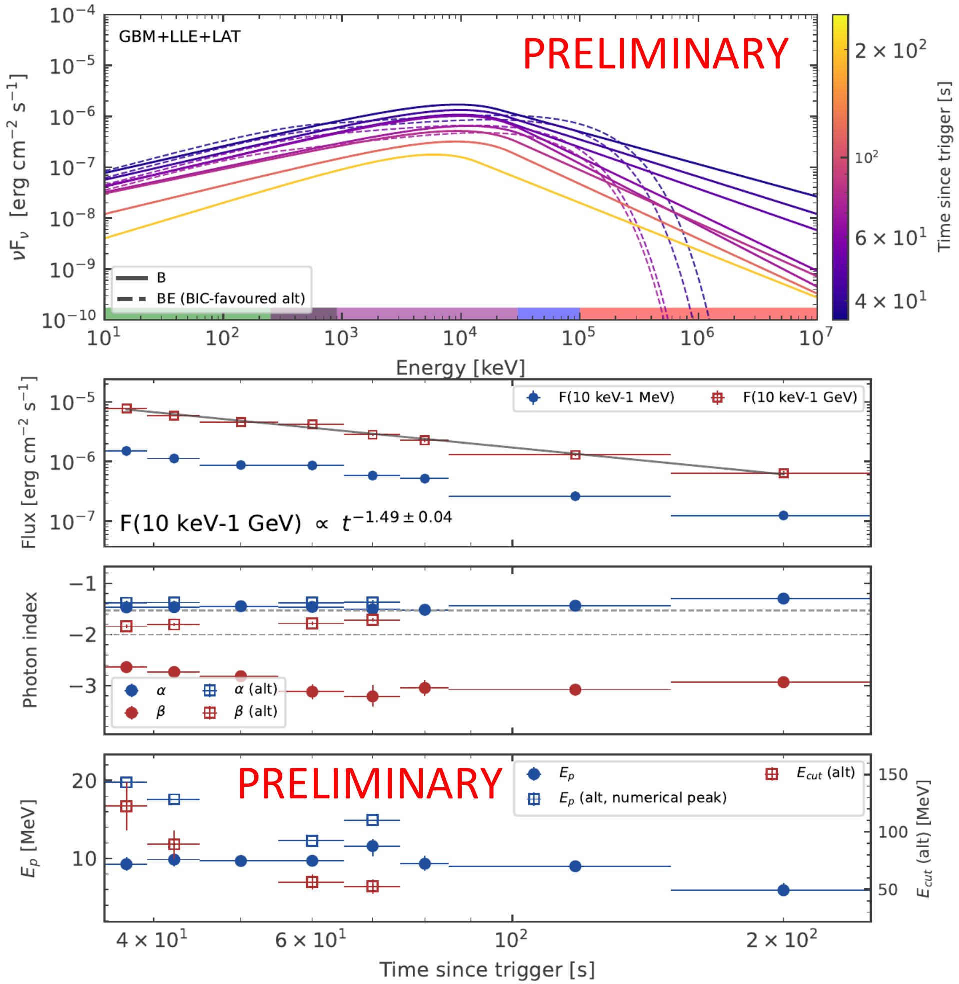
afterglow peak energy, at fixed spectral index

- Best-fit model is the sum of two Cutoff Powerlaw components throughout.
- Component 2 emerges with Ep2 descending 91 → 25 MeV at **constant spectral shape α2 ≈ -1.53**, matching the Phase D α value.
- **The prompt component collapses past 31 s**: Ep1 657 ± 22 → 359 ± 29 keV, flux ×3.7 down, while component 2 is ~ unchanged.
- Transition phase ends 32.4–35.3 s, supported by three independent methods (BB, MVT, spectrum).

A frozen spectrum and a single power-law decay

D





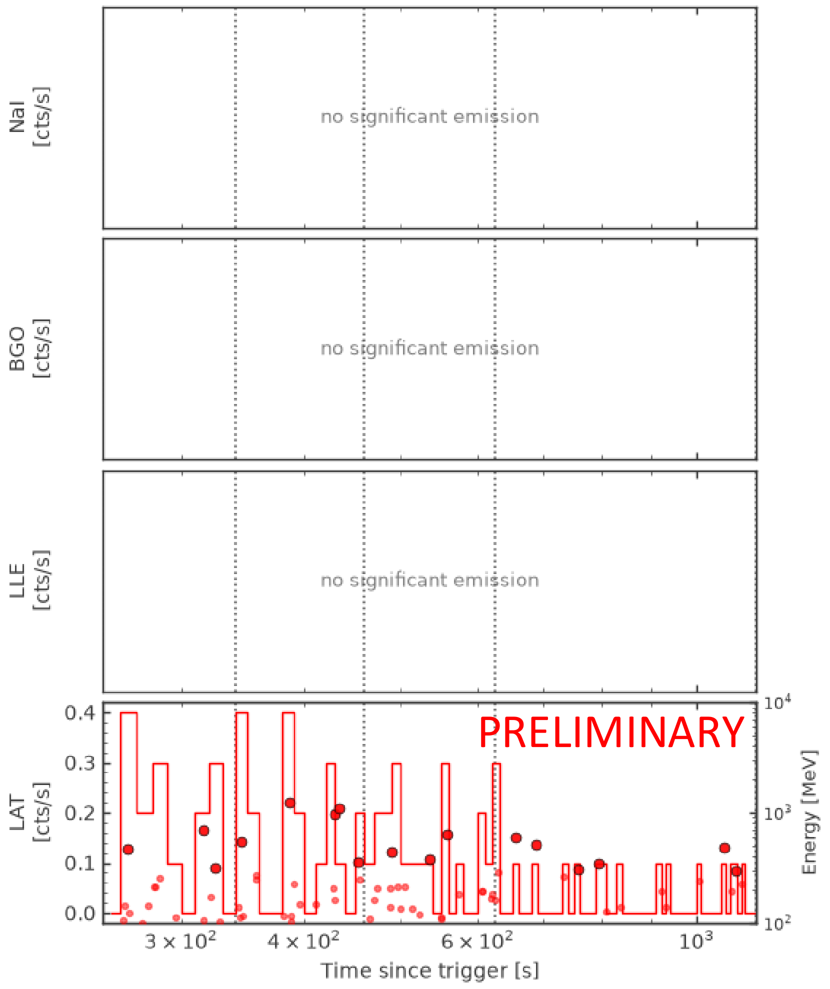
$t^{-1.49 \pm 0.04}$

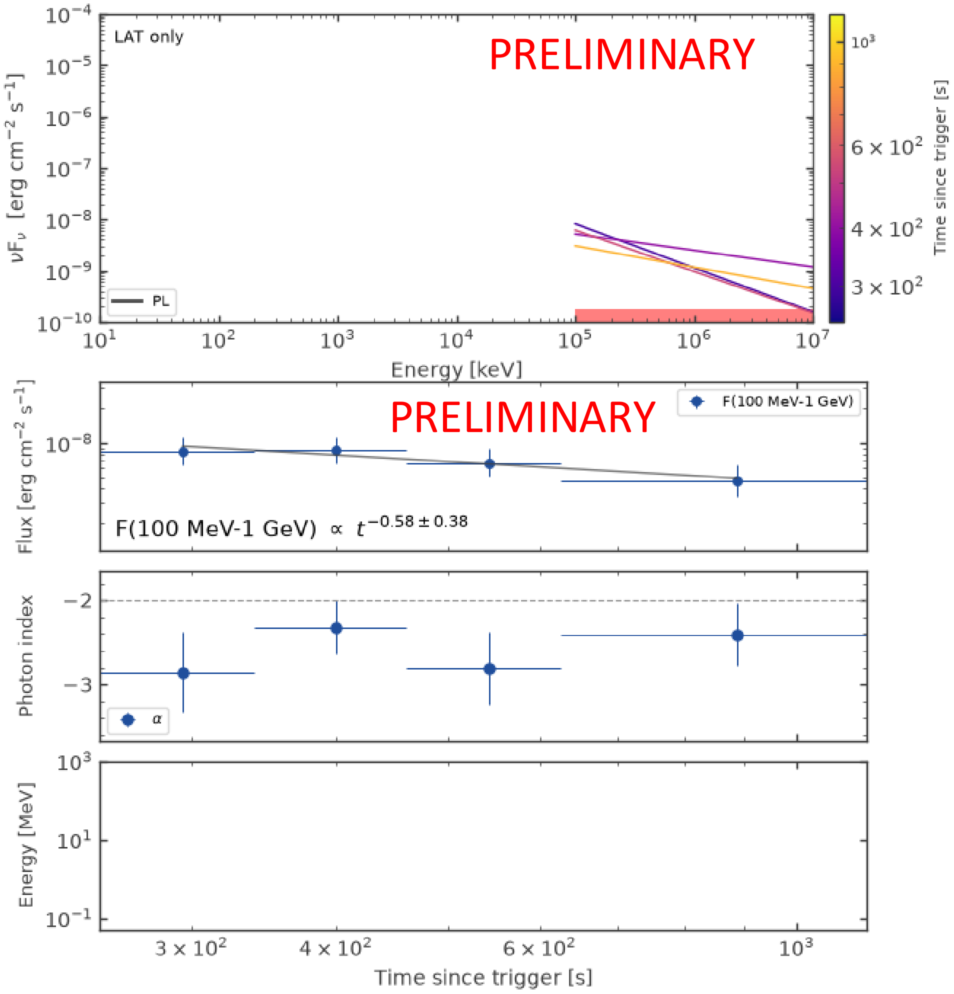
single power law decay, 35 to 250 s with no break

- Consistent with a **fully radiative Blandford–McKee blast wave**, index −10/7 at 1.1σ. An adiabatic index of −1 is excluded at 6.5σ.
- Best-fit model is a single Band (or Band x ExpCutoff) with a **frozen spectral shape**: Ep ≈ 9–10 MeV, α ≈ −1.44.
- **High-energy cutoff statistically preferred in four bins** (50–120 MeV) at t < 80 s.
- Bolometric to LAT-band flux ratio flat at 13–39, so the LAT band tracks a fixed fraction of the total.

LAT detection lasts ~ 19 min and the decay flattens

E





1111 s

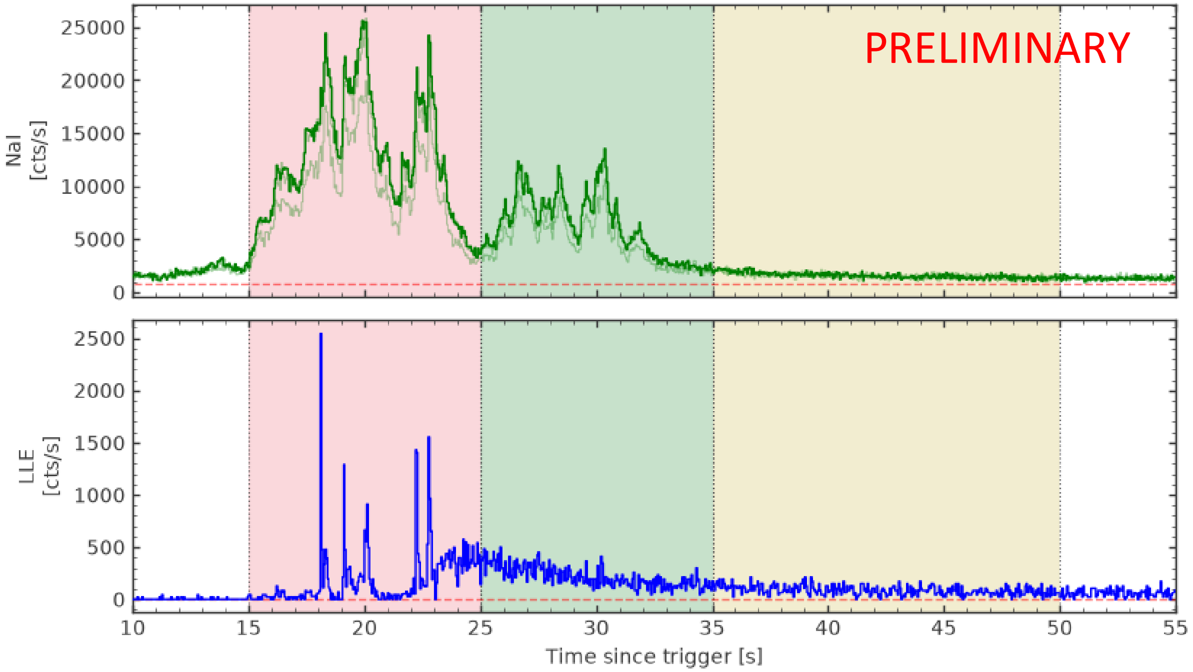
time of the last LAT-detected photon associated to the GRB

- LAT-only emission detected in four intervals (TS = 25–73), up to T0+1150 s, when the GRB became too off-axis and went out of the LAT FoV.
- Flux decay index flattens compared to the previous phase (blast wave left the radiative regime?).
- Photon index roughly constant at −2.6 ± 0.2, with no significant evolution.
- No GBM or LLE coverage beyond 250-300 s, so no bolometric flux or Epeak is reported.

Minimum variability timescale confirms the decomposition

Interval	NaI 8–900 keV	LLE 30–100 MeV	LLE / NaI
15 – 25 s	35.6 +6.9 / −9.9 ms	12.4 +3.5 / −3.7 ms	0.35×
25 – 35 s	40.9 +20.8 / −11.4 ms	$\gtrsim$ 2.4 s	$\gtrsim$ 59×
35 – 50 s	404 +84 / −75 ms	$\gtrsim$ 4.6 s	$\gtrsim$ 12×

Credit: Suman Bala



- LLE gives consistent values when the interval is split at 23 s instead, where the LLE light curve changes from spiking to smooth. GBM is not split there because truncating the peak biases the timescale low.
- In the prompt phase LLE varies 2.9× faster than NaI. Faster variability at higher energy is the standard signature of internal dissipation. $R \simeq 2c\Gamma^2 t_v/(1+z)$ with $t_v = 12.4$ ms gives $R \sim 10^{12}$–10^{13} cm for $\Gamma = 100$–200, which is three orders of magnitude below an external shock at these epochs.
- At 23 s the LLE timescale jumps ×194 while NaI is unchanged up to 35 s, then it jumps ×10. The two bands lose their variability ~12 s apart, consistent with the spectral analysis results.

GRB 260226A, two components with constant spectral shapes

COMPONENT 1 · PROMPT

present from ~−2.3 s to 32.4-35.3 s

- $\alpha \approx -0.7$ to -1.1 throughout and $\beta_1 \approx -2.3$ (with a cutoff)
- E_p rises 160 → 700 keV, then collapses 657 → 359 keV as the prompt emission dies
- Climbing high-energy cutoff ≈ 26 → 70 MeV
- Spectrum progressively extending upward in energy, consistent with declining opacity in the jet

COMPONENT 2 · AFTERGLOW

present from ~23 s to 1150 s

- $\alpha_2 \approx -1.50$ from the moment it appears, consistent with fast cooling regime
- νF_ν peak 91 → 25 MeV in Phase C, then frozen at 9–10 MeV
- High-energy cutoff ≈ 50–120 MeV at earlier times
- Bolometric flux decays with index -1.49 ± 0.04 (no break), consistent with a fully radiative blast wave up to ~ 250 s

Component 2 caught appearing at 23 s, while the prompt emission is still bright, and already carrying the spectral index ($\alpha \approx -1.5$) it keeps for the next four minutes. Its bolometric flux then decays as a single unbroken power law of index −1.49, the fully radiative Blandford–McKee solution, with the adiabatic t^{-1} excluded at 6.5σ. Spectral shape and temporal decay agree independently, and both say the early blast wave radiates essentially all the energy it dissipates, unlike the energy-conserving shocks inferred from afterglows observed hours later.

Apparent model changes over time track instrument coverage, not source evolution (underlying parameters remain consistent)

Thank you!
Questions?

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BACKUP SLIDES

SUMMARY

GRB 260226A, from −2.3 s to 1150 s

A Emission begins 17 s before the bright prompt pulses, non-thermal, with E_p climbing at 5σ. Nothing above 30 MeV.

B The prompt phase has an energy-dependent pause and a high-energy cutoff climbing 26.5 → 69.8 MeV.

C From 23 s a second component appears with $\alpha_2 = -1.53$, already the afterglow value, while the prompt component dies at 8.2σ by 32.4 s.

D The afterglow decays as a single power law of index −1.49 ± 0.04 with a frozen ~10 MeV spectrum — a fully radiative blast wave at 1.1σ.

E LAT detects the source to 1150 s with a constant photon index; the decay flattens at 3.2σ.

One prompt and one afterglow component, each with a constant spectral shape, describe the whole burst. The 1–100 MeV band is what makes the decomposition possible.

Same burst, same data, three analyses

	Banerjee et al. *(arXiv:2607.26129)*	**Huang et al.** *(arXiv:2607.27650)*	**This work**
Coverage	GBM + LLE + LAT to 1 GeV	GBM + LAT to 100 GeV (no LLE, 30–100 MeV)	GBM + LLE + LAT to 10 GeV
Onset	Analysis starts at T_0 + 14 s	T_0 − 2.2 s, one bin up to 15.1 s E_p = 292 (+60 / −48) keV	T_0 − 2.3 s, six bins up to 15 s E_p 159 → 377 keV (5.2σ)
High-energy cutoff 18–23 s	43 and 59 MeV, two bins	4.85 (+1.60 / −0.59) MeV one bin	26.5 → 69.8 MeV, four bins
Extra component	Afterglow; external IC in a pair-loaded stellar wind	Internal; IC of photospheric seed photons	Afterglow; α_2 ~ −1.5 already matches Phase D
Decay	Bolometric $t^{-1.5}$ then $t^{-2.8}$	LAT band only, $t^{-1.10}$ referenced to T_0 + 15.1 s	Bolometric $t^{-1.49}$, no break
Late LAT photon index	—	−2.84 ± 0.26	−2.6 ± 0.2

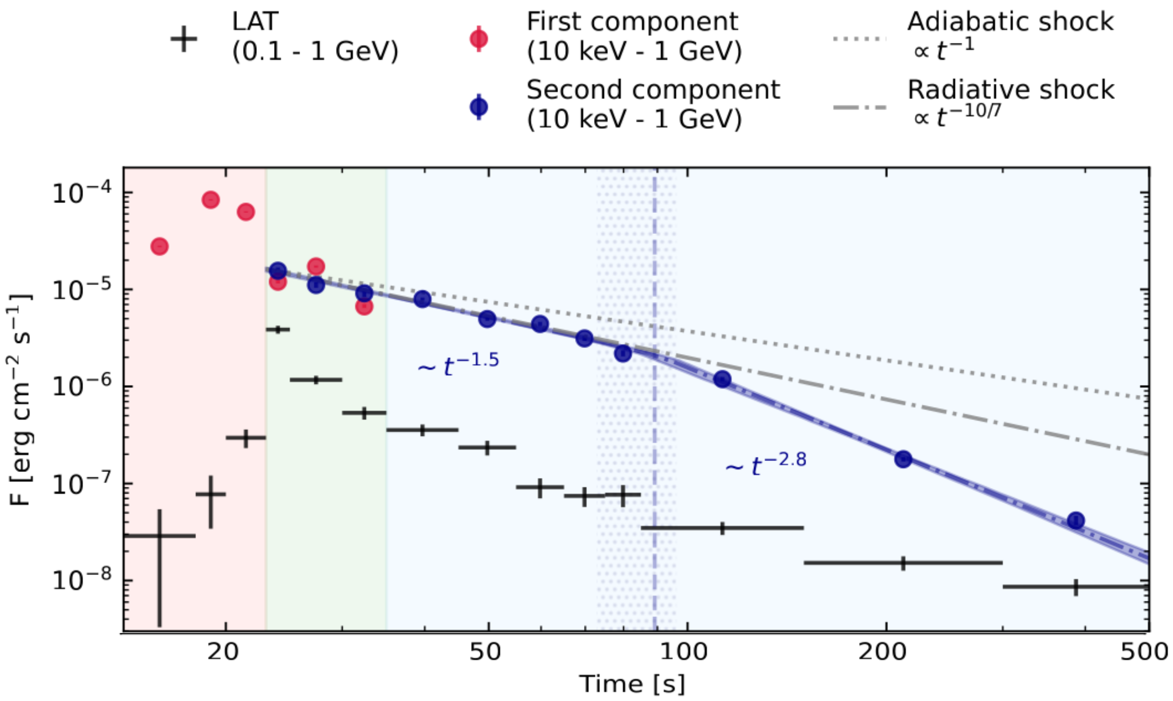
Huang+26 place the extra component in internal-shock electrons scattering photospheric seeds at 24–78 s. In the same 25–35 s window NaI still varies at ~41 ms while LLE shows nothing faster than 2.4 s — both the seeds and the scatterers would come from dissipation that is still varying, and that structure would have to be suppressed ≳50× in the IC component alone.

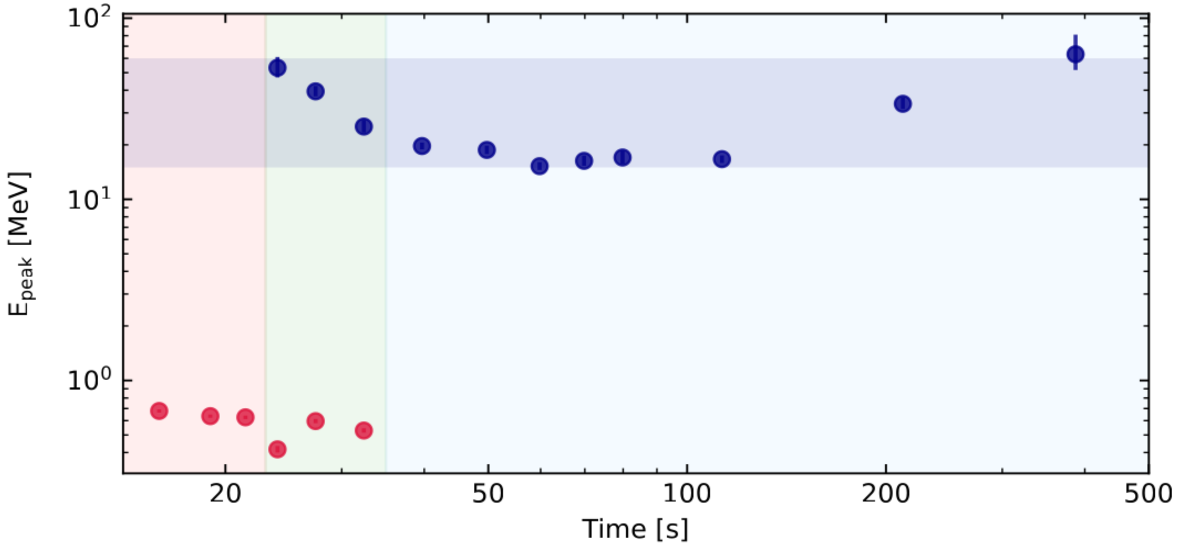
Comparison with Banerjee et al. paper

Cutoff Powerlaw (published, with OSV)	Cutoff Powerlaw (this analysis)	Band (this analysis)
Flux [10 keV–1 GeV] = 1.80×10^{-7} erg cm^{-2} s^{-1}	Flux [10 keV–1 GeV] = 2.60×10^{-7} erg cm^{-2} s^{-1}	Flux [10 keV–1 GeV] = 5.40×10^{-7} erg cm^{-2} s^{-1}

Band preferred: Δ BIC > 100

- In the 150–300 s and 300–500 s bins the GBM data no longer anchor the low-energy side, and the CPL fit raises Ep to accommodate the LAT points, and the bolometric flux drops with it.
- But LAT recorded 8 photons above 500 MeV across these two intervals (3 and 4), including one at 1.1 GeV that lies above the 1 GeV cap of their fit. The published CPL predicts ~ 0.03 and ~ 0.25 such events.





Banerjee+26 https://arxiv.org/pdf/2607.26129